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The Effect of a Progressive Weight Training Program on Arm and Leg Strength, Resting Heart Rate, Body Adipose Tissue, and Selected Body Measurements of College Freshman Women

Vicky Lynn Larson

THE EFFECT OF A PROGRESSIVE WEIGHT TRAINING PROGRAM ON ARM AND LEG STRENGTH, RESTING HEART RATE, BODY ADIPOSE TISSUE, AND SELECTED BODY MEASUREMENTS OF COLLEGE FRESHMAN WOMEN

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

VICKY L. LARSON

Under the Supervision of Professor Glenn E. Robinson

The purpose of this investigation was to determine the relative effects of a progressive weight training program on the arm and leg strength, resting heart rate, body adipose tissue, and selected body measurements of college freshman women.

Thirty students were selected randomly from volunteers from all of the freshman women enrolled in the required freshman physical education program at South Dakota State University, equated by a strength test designed by the writer, and randomly placed in an experimental or control group.

The experimental group participated in a progressive weight training program over a seven week period. Six exercise stations on a commercial device, the Marcy Gymnasium, were used in the training program. Each subject selected a resistance (weight) which she could lift four or five times in one set and continued to exercise with that particular weight until she could perform ten repetitions in one set. At this point in the program the weight was increased. The subjects progressively added weight during the training program.

Initial and final tests were administered to both groups to determine strength measurements, adipose tissue measurements, selected body measurements, and resting heart rate.

From this study the following conclusions were drawn:

1. Both the experimental and control groups increased in strength development; however, the exercises used in the weight training program employed in this study did not produce a significant increase of strength in right or left elbow flexion, right or left elbow extension, left knee flexion, and right or left knee extension of the experimental group over the control group. There was a significant increase in right knee flexion at the five percent level.

2. The weight training program as employed in this study had no significant effect on resting heart rate.

3. There was a significant loss of adipose tissue on the cheek, chest, arm, back, hip, and abdomen of the experimental group.

4. The weight training program as employed in this study had no significant effect on any of the selected body measurements.

ACKNOWLEDGMENTS

The writer wishes to express her sincere appreciation for the valuable help and guidance given by her Adviser, Professor Glenn E. Robinson. An expression of thanks is also extended to Instructor William B. Fritz and Dr. W. Lee Tucker, Statistician.

The writer also expresses her gratitude to the students who gave of their time and effort in making this study possible.

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Chapter I

INTRODUCTION

Background For Study

Strenuous physical activity and athletics for women have been and still are controversial matters. Too often in our culture strength has been associated with men, and softness and feminity with women. Women have not been desirous of developing strength because they are apprehensive of acquiring large muscles in doing so, and thereby becoming less feminine. However, from both the physiological and social points of view, this taboo is rapidly disappearing.

In discussing the place of women in our culture of today, Voltmer and Esslinger[1] made the following statement:

[1]Edward F. Voltmer and Arthur A. Esslinger, The Organization and Administration of Physical Education, p. 319.

> A woman has greater freedom today than ever before. More and more, she is participating in the social, political, and economic life of the world. If she is to fit harmoniously into this different life, she needs a different training. A valuable part of this training will be gained through competitive sports.

But it is recognized that all women do not wish to become competitors in athletics. However, many women are striving for an increase in strength development, an increase which may prove to be of value to them in every day life. In discussing the value of muscular strength

for women, Janet A. Wessel, in a paper written for the American Association for Health, Physical Education, and Recreation[2], states:

[2]American Association for Health, Physical Education, and Recreation, Weight Training in Sports and Physical Education, p. 106.

> Muscular strength is an asset for girls and women in their daily life, and that development and maintenance of strength is an investment in attractive appearance, optimal body function and top performance in homemaking and career, as well as sports activities.

Many weight training studies have been conducted for men, but to the writer's knowledge limited research relative to the effects of weight training for women has been completed.

The results of this study could prove helpful to women physical educators in providing a beneficial supplement or addition to their physical education program.

Statement of the Problem

The purpose of this study was to determine the relative effects of a progressive weight training program on the arm and leg strength, resting heart rate, body adipose tissue, and selected body measurements of freshman female students of South Dakota State University.

Limitations of the Study

1. This study was limited to 30 volunteer freshman female students enrolled at South Dakota State University the spring semester of 1967.

2. Physical education major students were not eligible for the study.

3. The subjects of the control group were urged not to participate in an activity course which might produce a considerable increase in strength. (Example - Body Mechanics)

4. No effort was made to control the eating, sleeping, drinking, and smoking habits of the subjects during the investigation.

5. The training period consisted of a seven week program with four meetings per week.

6. The specific exercise program was determined by the writer.

7. A commercial device, the Marcy Gymnasium, was used for the weight training program exercises.

Definitions

Weight Training--Leighton's[3] definition of weight training was accepted for use in this study. "The exercise phase of the

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[3]Jack R. Leighton, Progressive Weight Training, p. 3.

activity where weight is used to condition and alter the size of various segments of the body."

Progressive--The individual's capacity to undertake a gradual increase in resistance.

Strength--As defined by Riedman[4] is "... the capacity of the whole body or any of its parts to exert force."

[4]Sarah R. Riedman, Physiology of Work and Play, p. 516.

Resting Heart Rate--The number of heart beats in a 30 second period, as recorded on a physiograph.

Adipose Tissue--The subcutaneous layer of fat which is measurable with skinfold calipers because of very little fiberous connective tissue.

Warm-up--A group of exercises taken before starting any activity calling forth a maximun effort.

Overload--The driving of muscles to do work beyond that which is performed easily and comfortably, without reaching a point of undue strain.

Body Measurements--The height, weight, and girth of each subject, as measured in inches or pounds.

Chapter II

REVIEW OF RELATED LITERATURE

Introduction

A search of the literature revealed limited studies in the area of the physical aspects of weight training upon strength, heart rate, adipose tissue and body girth of women. The writer investigated the opinions of authors on the place of activity for women and related studies completed on male subjects which had implications for this study.

Report of Pertinent Findings

In dispensing the groundless fear concerning large muscles and feminity, Leighton[5] states:

> Actually muscles help to give shape to the body. If shape is present without muscular development, then this is either an angular shape given by the bones or a more lumpy shape produced by the presence of body fat. A certain amount of muscular development is a necessity for all persons. Women will actually be more attractive because of it than without it. Fat areas will be reduced and flabby or loose areas will become firm through proper diet and exercises to bring about this necessary muscular development. At Eastern Washington College of Education, the girls in the weight-training program lost, on the average, one inch in circumference from each of three areas—the thigh, the hips, and the waist—and some added to their bust measurements. They felt better physically at the completion of the course than they did at its beginning.

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[5]Leighton, op. cit., p. 8.

> The qualities of physical fitness are every bit as desirable in a woman as they are in a man. Possessing them will not make a woman less feminine and certainly not less attractive. After all, many beauty contest winners and professional models use this method to maintain their attractiveness.

Wessel, in a paper for the American Association for Health, Physical Education, and Recreation[6], has indicated that weight training is a form of progressive resistance exercise. Being progressive, it is easily adapted and adjusted to each girl's capacity and ability and her personal interests and needs. She asserts that the idea prevailing among girls and women that weight training or any form of exercise develops bulky muscles must be dispelled. This can be accomplished in two ways:

> (1) By bringing recognition to the conditioning and strengthening value of progressive resistance exercises.
>
> (2) By disseminating information of what we now know--that muscular strength is an asset for girls and women in their daily life, and that the development and maintenance of strength is an investment in attractive appearance, optimal body function, and top performance in homemaking and career, as well as sports activities.

Wessel continues by stating in her procedures for exercise routines:

> All work performed should be on an individual basis. Each girl should be assisted in finding the

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[6] American Association for Health, Physical Education, and Recreation, op. cit., p. 106.

> amount of resistance (weight) she should use to begin her routine. Trial and error with guidance by the instructor is the best method of establishing the proper amount of resistance. It is recommended that the girl set a resistance which she can lift four or five times and that she continue to exercise with this weight until ten repetitions are performed. At this point, the weight is increased by a suitable amount--two and one-half to ten pounds--and the repetitions are again reduced to five.

Wessel also says that a warm-up routine may be employed before any lifting with weights. This general warm-up period should last about two to five minutes.

The overload principle, according to Taylor[7], is the basis for success of all programs of weight training. Taylor states:

> The principle of overload or progressive resistance applies to female and male muscles: both develop through being made to work against a resistance which increases progressively as the muscle develops. There need be no fear of strain or excessive development of muscle bulk if the training program is carefully graded to each individual's ability.

Taylor further indicated that weight exercises which have proved effective for men could be suitable for women, provided that adjustments are made to poundage and repetitions according to each individual's ability. Taylor commented:

> Movement by movement, there is little difference between a man's performance and that of a woman in the same athletic event. The mechanics of the muscle

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[7]Eric Taylor, Training With Weights, p. 142.

> action in putting the shot for example, are the same for a man as for a woman. It seems sensible then for women to employ training methods which have been successful in improving the men's ability.

In discussing the effects of exercise on women Klaus and Noack[8] state "that due to the protein catabolic effect of the female hormones, women have limited trainability with respect to muscle bulk and strength development".

In the Physical Education Activities Series on Weight Training, Rasch[9] has said that exercises which do not involve overloading the body systems have relatively little effect upon performance ability. He further comments that exercise will increase an individual's capacity to perform physical activity and to recover more quickly from fatigue. Exercise may thus make life more enjoyable.

Karpovich[10] has written concerning the development of strength:

> The only way to develop strength of muscles is to exercise them gradually increasing resistance. For this purpose, one can use springs, weights, or the

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[8] E. J. Klaus and H. Noack, Frau und Sport, p. 3.

[9] Philip J. Rasch, Weight Training, p. 6.

[10] Peter V. Karpovich, Physiology of Muscular Activity, p. 33.

> weight of the body itself. Even though the same method of training is used, the rapidity and the ultimate degree of development in different persons will be different.

Nagle and Irwin[11] investigated the effects of two systems of weight training on circulorespiratory endurance and related physiological factors. The writers compared the effects of high and low repetition systems on circulorespiratory endurance. Despite some indication of weight training effects, they concluded that weight training has no significant effects on certain physiological responses to exercise or on circulorespiratory endurance to which these responses are related. This conclusion holds for weight training systems utilizing five to fifteen repetitions per set.

[11]Francis J. Nagel and Leslie W. Irwin, "Effects of Two Systems of Weight Training on Circulorespiratory Endurance and Related Physiological Factors," Research Quarterly, December, 1960, p. 614.

In the relationship of blood volume to fat tissue Guyton[12] believes that the greater the obesity the lesser the blood volume per unit weight, because fat tissue has little vascular volume. In very heavy females, who are especially prone to have a high ration of fat tissue to lean tissue, the blood volume per kilogram decreases more than for males. The average female, because of a far greater fat-to-lean tissue ration than that of the average male, has a blood volume about 20 percent below that of the male.

[12]Arthur C. Guyton, Textbook of Medical Physiology, p. 419.

McLester and Darby[13] believe that too much fat interfered

[13]James S. McLester, William J. Darby, Nutrition and Diet in Health and Disease, p. 334.

materially with physical activity, reduced muscular efficiency, and when found in excessive amounts in the abdominal cavity, interfered with movements of the diaphragm and abdominal muscles.

Roby[14] studied the effect of exercise on regional subcute-

[14]Fred B. Roby, "Effect of Exercise on Regional Subcutaneous Fat Accumulations," Research Quarterly, May, 1962, p. 273.

neous fat accumulations. Roby used a Harpenden skinfold caliper to estimate the thickness of the subcutaneous fat layers. The findings did not support the postulate that subcutaneous fat is reduced in localities where muscles are active nor was the proportion of muscular activity a pertinent factor.

In writing about the kinesiology of weight lifting, Massey, Freeman, Hanson and Wessel[15] believe that fatty tissue is reduced but

[15]Benjamin H. Massey, Harold W. Freeman, Frank A. Hanson, Janet A. Wessel, The Kinesiology of Weight Lifting, p. 11.

that the body during exercise does not confine its demands for energy to the area being exercised. Rather it is more likely that the energy will be derived from fat deposits throughout the body.

Rasch[16] indicated in the Physical Education Activities

[16]Rasch, op. cit., p. 57.

Series on Weight Training "that there is no such thing as an 'official' set of prescribed body measurements, but most of the recommendations made by Willoughby about twenty years ago have been generally accepted and comprise the present practice."

Summary

In the writer's opinion the review of the literature, for the most part, indicated agreement that a weight training program had a positive effect on strength development and loss of adipose tissue, but no significant change in circulorespiratory endurance. There seemed to be agreement that weight training for women would not produce adverse effects either physiologically or sociologically. The review of literature and the opinions of authors assisted the writer in formulating a training program to determine the physiological effects of weight training on freshman college women.

Chapter III

PROCEDURE FOR OBTAINING DATA

Introduction

The subjects, the explanation of the initial and final measures, and the description of the training program are included in this chapter.

Subjects

The 30 subjects were randomly selected from 122 volunteer freshman women enrolled in the basic instruction program of physical education during the spring semester of the 1966-1967 school year. Ages of the subjects ranged from 18-20 years. The 30 subjects were divided into two equated groups by a cable-tension strength test designed by the writer. Three tests were employed: the bench press, a strength measurement on the right leg, and a strength measurement on the left leg. The cable tensiometer was used to obtain the number of pounds pulled. Three trials were given for each test. The best of the three trials constituted the raw score for each test. The raw scores for the bench press, right leg strength, and left leg strength were totaled. This total constituted a final score of total pounds pulled by each subject. This data may be found in Appendix A. A rank-difference coefficient of .765 was obtained between the elbow flexion, elbow extension, knee flexion, and knee extension test

designed by Clarke[17] and the strength test designed by the writer.

[17]Harrison Clarke, Cable-Tension Strength Tests, pp. 16 & 29.

The control and experimental groups were designated by use of the track pillbox method.

The study lasted for a period of seven weeks, from February 14, 1967, to March 31, 1967. The subjects in the experimental group completed 24 training sessions. Four sessions were missed because of Easter vacation. The subjects in the control group attended their regular physical education classes and proceeded without change through their daily school schedule. On February 6, 7, 8, and 9 the initial strength tests were administered to the two groups. In addition, the resting heart rate was determined, and adipose tissue and selected body measurements were taken. On April 3, 4, 5, and 6 the final post-tests were administered. A standard testing procedure was followed during all tests. Data was recorded on special forms which may be found in Appendix B.

All subjects received oral instruction to continue their normal habits of sleeping, eating, drinking, and smoking during the experiment. The control group was urged not to enroll in a body mechanics class for the first nine weeks of the spring semester.

Measurements

The following measurements were taken prior to the start of the training program and at the completion of the program:

Strength

Four strength tests--elbow flexion, elbow extension, knee flexion, knee extension--were administered to each subject. These cable-tension strength tests were originated by Clarke[18]. All tests

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[18] Ibid.

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were given for both right and left appendages. During each test three readings for each subject were taken with a calibrated cable tensiometer. The best of the three readings constituted the raw score.

A trained assistant was used to help with the administration of these strength tests. All subjects were encouraged to put forth maximum effort.

Elbow Flexion (Figure 1)

Starting position: Subject in supine lying position; hips and knees flexed; feet resting on table; free hand resting on chest. Upper arm on side tested is adducted and extended at shoulder to 180 degrees; elbow in 115 degrees flexion; forearm in mid-prone supine position.

Attachments: Regulation strap around forearm midway between wrist and elbow joints; pulling assembly hooked to wall at subject's feet. The tensiometer was attached to the cable, and on

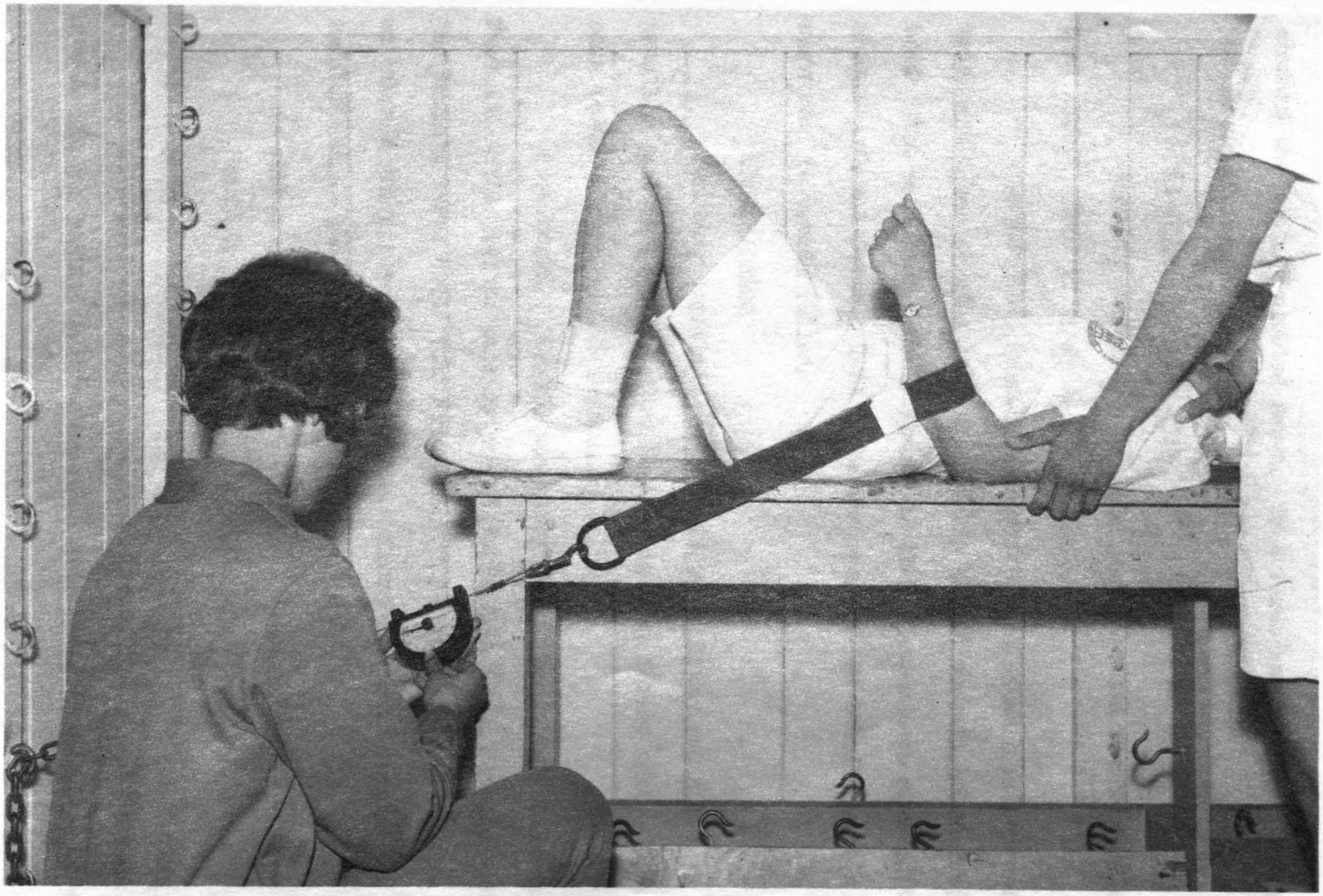

Figure 1. Cable-Tension Strength for Elbow Flexion

command the subject exerted force. This force was recorded in tension pounds and converted to pounds pulled.

Elbow Extension

Starting position: The same position used for Elbow Flexion, except elbow is in 40 degrees flexion.

Attachments: Regulation strap around forearm midway between wrist and elbow joints; pulling assembly hooked to wall below subject's head. The tensiometer was attached to the cable, and on command the subject exerted force. This force was recorded in tension pounds and converted to pounds pulled.

Knee Flexion

Starting position: Subject in prone lying position; patellae just at edge of table; head resting on folded arms. Knee on side tested flexed to 165 degrees.

Attachments: Regulation strap around leg midway between knee and ankle joints; pulling assembly attached to an extension of the table's lower end. The tensiometer was attached to the cable, and on command the subject exerted force. This force was recorded in tension pounds and converted to pounds pulled.

Knee Extension (Figure 2)

Starting position: Subject in sitting position; arms extended to rear; hands grasping sides of table.

Attachments: Regulation strap around leg midway between knee and ankle joints; pulling assembly attached to hook at lower end

Figure 2. Cable-Tension Strength for Knee Extension

of table. The tensiometer was attached to the cable, and on command the subject exerted force. This force was recorded in tension pounds and converted to pounds pulled.

On all strength tests a goniometer was used to measure the angle of degrees.

Resting Heart Rate

Resting heart rates were recorded graphically by means of an E and M Physiograph, a precision measurement and recording system used for physiological experimentation in research.

Upon her arrival at the laboratory each subject rested in a sitting position for a 10-minute period. Following the rest period a Crystal Pulse Pick-Up Transducer for peripheral arterial pulse wave detection was attached to the subject to graphically record the subject's pulse rate for 30 seconds.

The Crystal Pulse Pick-Up Transducer was connected to a Hi-Gain Preamplifier, and the Hi-Gain Preamplifier was connected to a Channel Amplifier by means of a transducer cable. The Channel Amplifier mounted in the E & M Physiograph Main Frame was a part of the physiograph recording channel. By means of this hook-up a radial pulse tracing for each subject was obtained.

Adipose Tissue

Three measures of adipose tissue were recorded in centimeters at each site by use of skinfold calipers manufactured by the MNL-Medical Nutrition Laboratory, Denver, Colorado (Figure 3). The

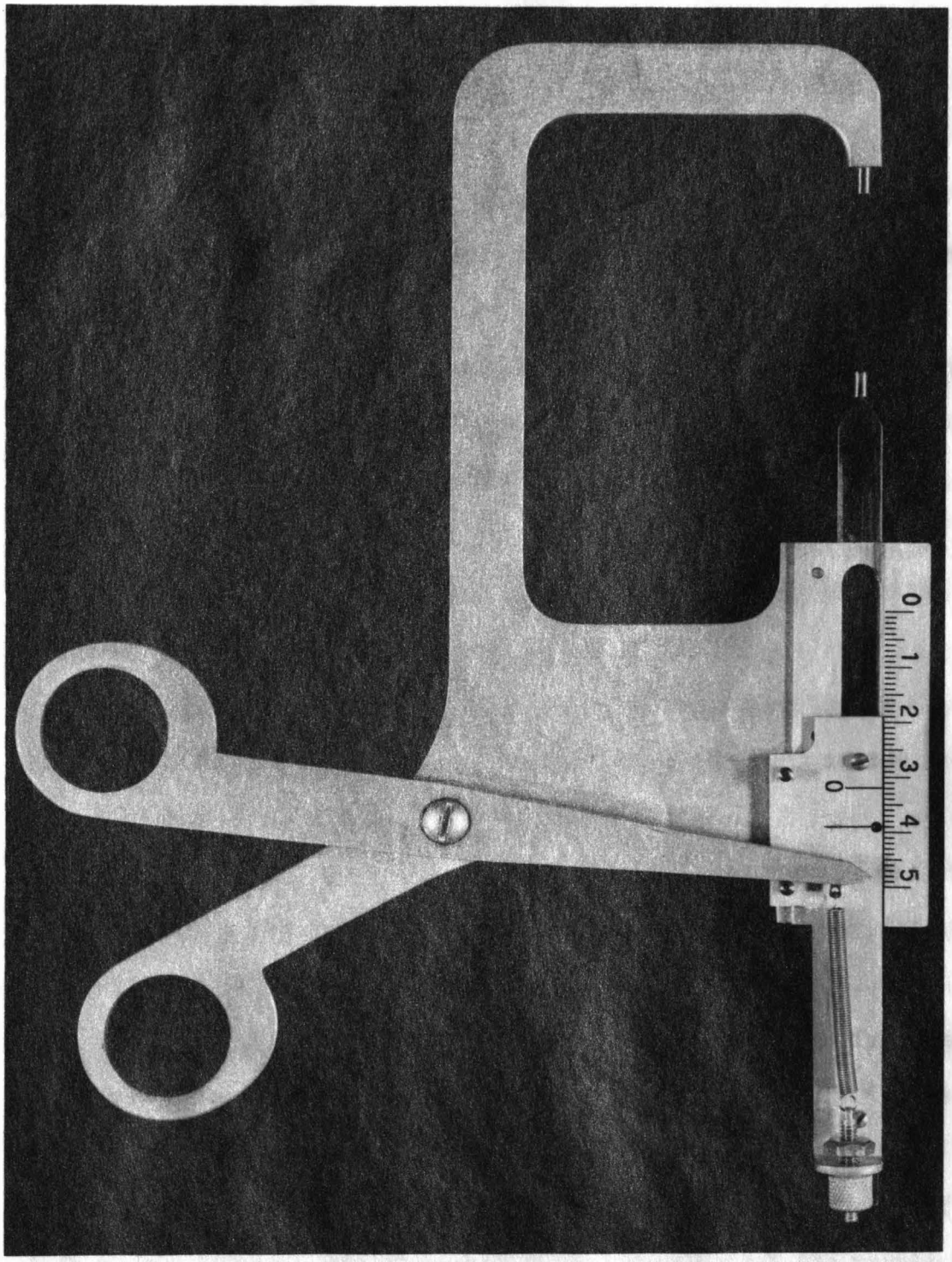

Figure 3. MNL-Medical Skinfold Calipers

data recorded in centimeters was the mean of the three measurements. This mean measurement for each subject constituted the raw score for this study.

Skinfold measurements were taken on the following sites:

Cheek: The measurement was made on the right cheek, level with the lower part of the nose, at the center of the cheek.

Upper Arm: The measurement was taken over the right triceps, half way between the olecranon and acromial processes. The skinfold was taken parallel to the long axis of the arm, with the arm held at a 90-degree angle.

Back: The measurement for the back was taken under the scapula, parallel to the vertebral column.

Hips: The measurement was made on the right hip at a point located at the center of the sagittal plane of the body and at the top of the crest of the ilium or hip bone.

Abdomen: The measurement was taken approximately 5 centimeters to the right of the umbilicus. The skinfold was orientated laterally.

Chest: The measurement was taken 5 centimeters from the right nipple on a line toward the uppermost point of the axillary fold, with the skinfold parallel to this line.

A skinfold was taken with the thumb and index finger of the left hand. The skin was pinched and pulled away from the muscle and held from 1 to 1.5 centimeters away from the fingers. Standard pressure was exceeded at first to allow the body fluids to shift, and

then the measurements were made by placing the jaws of the calipers below and in line with the tips of the thumb and forefinger. Pressure was placed on the calipers, and when the indicators stopped, the result was recorded in centimeters.

Body Measurements

Body weight was recorded to the nearest one-eighth pound. Body height was recorded to the nearest one-fourth inch. Body girth measurements were recorded to the nearest one-eighth inch.

Body Weight: The subjects were weighed in their underclothing on a doctor's scale manufactured by the Continental Scale Corporation of Chicago, Illinois.

Body Height: The subjects were measured by a stadiometer located on the weighing scale.

Body Girth was recorded at the following points:

(1) Bust: Measurement was taken with the tape measure running directly over the nipples and laterally around the back.

(2) Waist: Measurement was taken approximately 5 centimeters above the ilium.

(3) Hips: Measurement was taken laterally around the largest portion of the hips.

(4) Right and Left Arm: Measurement was taken half way between the olecranon and acromial processes.

(5) Right and Left Thigh: Measurement was taken over the largest part of the thigh which, in most persons, is over the quadriceps muscle about four to eight inches below the hip joint.

(6) Right and Left Calf: Measurement was taken laterally around the largest part of the gastrocnemius.

(7) Right and Left Ankle: Measurement was taken around the smallest part, usually about two inches above the lateral and medial malleolus.

Training Program

The subjects of the experimental group received two days of orientation concerning safety procedures and fundamentals of the exercises prior to the actual training program. They did not actually lift weights at this time.

During the training program itself the 15 subjects in the experimental group met 24 times during a seven week period. Each subject reported to the weight training room at a specified time on each Monday, Tuesday, Thursday, and Friday, and worked to her own capacity. The subjects progressively added weight during the training program. The raw data for the program appears in Appendix E.

The entire weight training program was designed for use with the Marcy Gymnasium (Figure 4). The initial weight for each subject for a given exercise was determined by the writer through

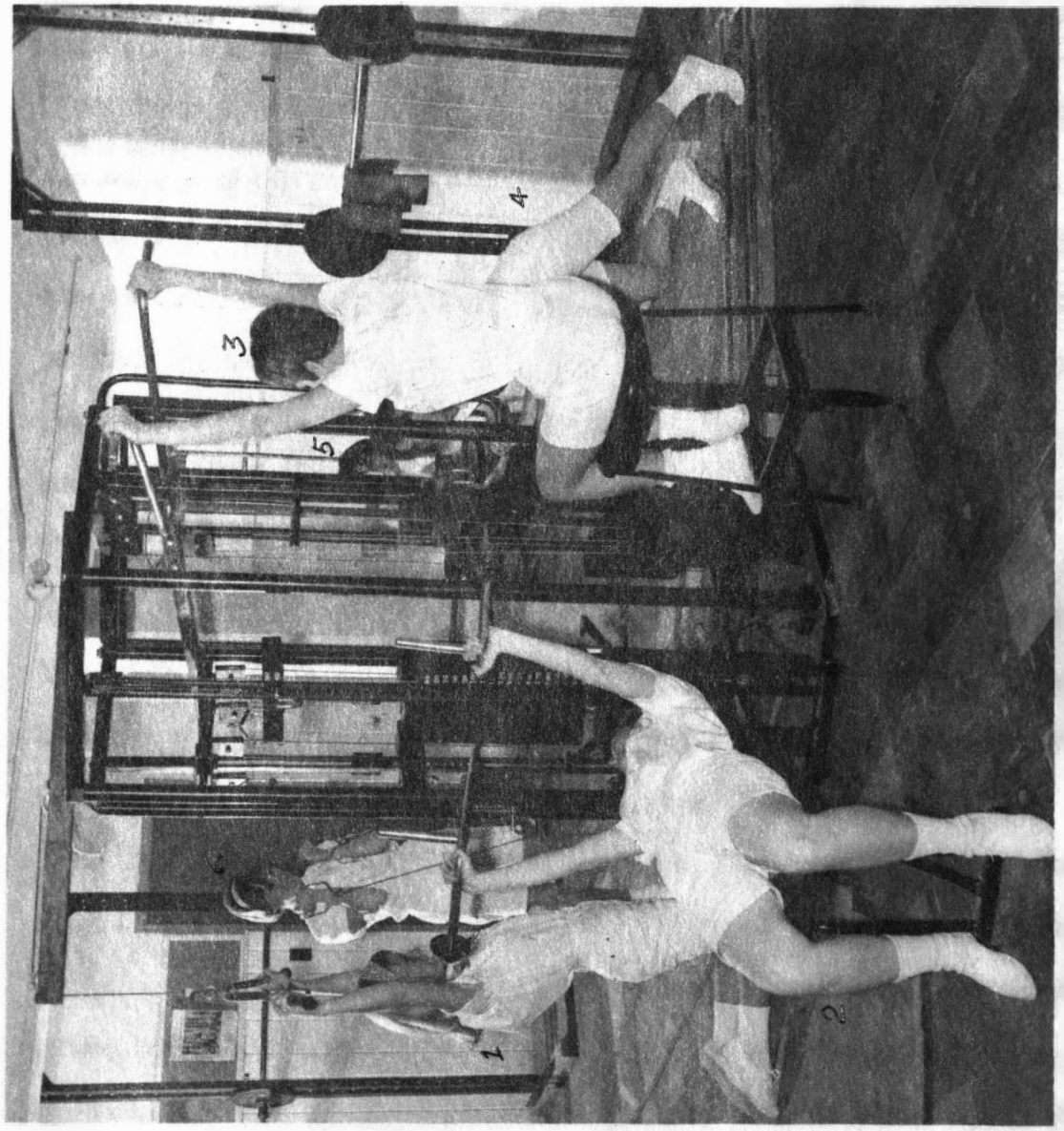

Figure 4. Marcy Gymnasium

trial and error. The program was conducted in accordance with the recommendation reported in a paper by Wessel for a text published by the American Association for Health, Physical Education, and Recreation[19]. Wessel recommended that a girl select a resistance

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[19]American Association for Health, Physical Education, and Recreation, op. cit., p. 112.

(weight) which she could lift four or five times in one set and that she continue to exercise with that particular weight until she could perform ten repetitions in one set. At this point in the training program the weight should be increased by a suitable amount--two and one-half to ten pounds--and the repetitions again reduced to five. The bench press on the Marcy Gymnasium could be increased by $1\frac{1}{2}$, $2\frac{1}{2}$, 5, or 10 pound intervals. However, the construction of the Marcy Gymnasium necessitated a ten pound increase in the weight interval on the lateral pull, military press, leg machine, and pulley machine. Because of a 10 pound increase at one time, the girls frequently could not complete five repetitions on the first attempt at the higher weight increase, but they were encouraged to do as many as possible.

A warm-up period, about 2 minutes in duration, was conducted prior to each workout. A description of the warm-up is found in Appendix C. Upon completion of the warm-up period, the subject would begin her exercises at Station 1.

The program consisted of six exercises stations; four were designed to strengthen the upper body, one was designed for the legs,

and one was designed for the abdominal region. Carnes[20] has stated,

[20]Jimmy Carnes, "Weight Training for Track," Scholastic Coach, February, 1961, p. 34.

"Since the arms always coordinate with the legs, it is important to stress this phase of the weight workout—making the upper body strong enough to move in coordination with the lower body."

The following exercises were used in the training program:

Station 1: Lateral Pull

Station 2: Bench Press

Station 3: Military Press

Station 4: Leg Machine

(a) Quadriceps exercise

(b) Hamstring exercise

Station 5: Sit-ups on an incline board

Station 6: Pulley Machine

(a) Bicep curls

(b) Tricep extensions.

A description of the exercise program is found in Appendix D.

The stations were constant for the entire training program. Each subject began with Station 1 and proceeded through to Station 6, performing each exercise once. A rest period of not less than one minute, nor longer than five minutes, was allowed between exercises. The time of rest, within these limits, was determined by each

individual and the investigator. The factor considered was the effects of fatigue of each subject. No rest was allowed within the execution of the exercise, and the exercise was executed in a continuous movement.

Chapter IV

ANALYSIS OF DATA

Introduction

The statistical analysis of the data (strength measurements; adipose tissue measurements; body girth measurements; and resting heart rate) appears in this chapter. The raw data appears in Appendixes F, G, H, I, and J.

Scoring of Data

The raw scores obtained from the resting heart rates and the body measurements required no conversion in this study. The raw scores from the cable-tension strength tests required that the tensiometer readings be converted into pounds pulled. The best of three readings was used as the raw score.

Three skinfold measurements were taken at each of the six sites for adipose tissue measurements. The mean of these three measurements was used as the raw score in this study.

The scoring of data and the statistical analysis was facilitated by the use of an electronic computer.

Reliability of Data

Strength

Four cable-tension strength tests as designed by Clarke[21] were used for this investigation. The cable tensiometer had been calibrated by a staff member of the Physics Department of South Dakota State University prior to the initial testing.

A pilot study was completed by the writer for a one-week period, under the observation and guidance of a faculty adviser. On termination of the pilot study, the writer was designated as being adequately prepared to administer the cable-tension strength tests.

Resting Heart Rate

The E & M Physiograph was reported as having a linearity of less than one percent of the full scale.

A pilot study was completed by the writer for a one-week period, under the observation and guidance of a faculty adviser. On termination of the pilot study, the writer was designated as being adequately prepared in the use of the E & M Physiograph. The physiograph recorded the resting heart rate for 30 seconds. The resting heart rate measures are quite variable and can be affected by outside factors.

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[21] Clarke, op. cit., pp. 16 & 29.

Adipose Tissue Measurements

The skinfold caliper technique for measuring adipose tissue was employed in this investigation. A pilot study was completed by the writer for a one-week period, under the observation and guidance of a faculty adviser. On termination of the pilot study, the writer was designated as being adequately prepared in the use of the MNL-Medical Skinfold Calipers.

Body Measurements

The use of a tape measure was employed in the taking of body girth measurements. A pilot study was completed by the writer for a one-week period, under observation and guidance of a faculty advisor. On termination of the pilot study, the writer was designated as being adequately prepared in using the tape measure for taking body girth measurements at the stated sites.

Analysis of Data

The analysis of data for this investigation dealt statistically with the variance or change within individuals between the initial and final tests. The difference between the experimental and control groups from initial and final tests was tested for significance at the five percent level by application of the F test. F ratios statistically significant at or beyond the five percent level necessitated a rejection of the null hypothesis.

For comparison between the experimental and control groups, 28 degrees of freedom were present, and the null hypothesis was rejected if the F ratio was equal to or greater than 4.20.

Findings Between Experimental and Control Groups

Table I shows the summary of F tests for mean change between initial and final tests for experimental and control groups on elbow flexion, elbow extension, knee flexion, and knee extension.

Strength

On elbow flexion the experimental group showed a mean gain of 15.80 pounds for the right arm and 12.13 pounds for the left arm. The control group showed a mean gain of 20.9 pounds for the right arm and 13.13 pounds for the left arm. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On elbow extension the experimental group showed a mean gain of 8.86 pounds for the right arm and 8.06 pounds for the left arm. The control group showed an average gain of 5.54 pounds for the right arm and 6.14 pounds for the left arm. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On knee flexion the experimental group showed a mean gain of 19.19 pounds for the right leg and 26.32 pounds for the left leg. The control group showed a mean gain of 7.73 pounds for the right leg and 22.0 pounds for the left leg. The F ratio of 4.44 on knee flexion of

Table I

Summary of F Test for Mean Change between Initial and Final Tests for Experimental and Control Groups (Pounds Pulled)

	Mean Change	df	F ratio
Elbow Flexion			
Experimental (right)	15.80		
Control (right)	20.90	28	.78
Experimental (left)	12.13		
Control (left)	13.13	28	.03
Elbow Extension			
Experimental (right)	8.86		
Control (right)	5.54	28	.66
Experimental (left)	8.06		
Control (left)	6.14	28	.23
Knee Flexion			
Experimental (right)	19.19		
Control (right)	7.73	28	4.44*
Experimental (left)	26.32		
Control (left)	22.00	28	.29
Knee Extension			
Experimental (right)	33.86		
Control (right)	25.54	28	1.13
Experimental (left)	38.60		
Control (left)	28.60	28	1.19

*Statistically significant at the five percent level.

the right leg was statistically significant at the five percent level of significance, and the null hypothesis was rejected. The F ratio of .29 on knee flexion of the left leg was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On knee extension the experimental group showed an average gain of 33.86 pounds for the right leg and 38.6 pounds for the left leg. The control group showed a mean gain of 25.54 pounds for the right leg and 28.60 pounds for the left leg. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

Resting Heart Rate

Table II shows the summary of F tests for mean change between initial and final tests of the experimental and control groups on resting heart rate and six measures of adipose tissue.

The experimental group showed a mean loss of .47 beats per 30 seconds. The control group showed a mean loss of 3.20 beats per 30 seconds. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

Adipose Tissue

The experimental group showed a mean loss of .12 centimeter of adipose tissue on the cheek. The control group showed a mean gain

Table II

Summary of F Test for Mean Change
Between Initial and Final Tests for
Experimental and Control Groups

	Mean Change	df	F ratio
Heart Rate (30 Sec.)			
Experimental	- .47		
Control	-3.20	28	2.58
Cheek (cm.)			
Experimental	- .12		
Control	.01	28	5.40*
Chest (cm.)			
Experimental	- .04		
Control	- .01	28	6.28*
Arm (cm.)			
Experimental	- .05		
Control	.02	28	6.97*
Back (cm.)			
Experimental	- .07		
Control	.09	28	25.72*
Hip (cm.)			
Experimental	- .07		
Control	- .00	28	11.69*
Abdomen (cm.)			
Experimental	- .12		
Control	.03	28	35.87*

*Statistically significant at the five percent level.

.01 centimeter of adipose tissue on the cheek. This difference was statistically significant at the five percent level of significance. The null hypothesis was rejected.

The experimental group showed a mean loss of .04 centimeter of adipose tissue on the chest. The control group showed an average loss of .01 centimeter of adipose tissue on the chest. This difference was statistically significant at the five percent level of significance. The null hypothesis was rejected.

The experimental group showed a mean loss of .05 centimeter of adipose tissue on the arm. The control group showed a mean gain of .02 centimeter of adipose tissue on the arm. This difference was statistically significant at the five percent level of significance. The null hypothesis was rejected.

The experimental group showed a mean loss of .07 centimeter of adipose tissue on the back. The control group showed a mean gain of .09 centimeter of adipose tissue on the back. This difference was statistically si gnificant at the five percent level of significance. The null hypothesi s was rejected.

The experimental group showed a mean loss of .07 centimeter of adipose tissue on the hip. The control group showed a mean loss of .00 centimeter of adipose tissue on the hip. This difference was statistically significant at the five percent level of significance. The null hypothesis was rejected.

The experimental group showed a mean loss of .12 centimeter of adipose tissue on the abdomen. The control group showed a mean

gain of .03 centimeter of adipose tissue on the abdomen. This difference was statistically significant at the five percent level of significance. The null hypothesis was rejected.

Body Measurements

Tables III and IV show the summary of F tests for a mean change between initial and final tests of the experimental and control groups on selected body measurements.

The experimental group and control group both showed a mean gain of .1 inch in height. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

The experimental group showed a mean gain in weight of 1.21 pounds. The control group showed a mean loss in weight of .55 pounds. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

The experimental group showed a mean gain in bust size of .44 inch. The control group showed a mean gain in bust size of .24 inch. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

The experimental group showed a mean gain in waist size of .40 inch. The control group showed a mean gain in waist size of .24 inch. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

Table III

Summary of F Test for Mean Change

Between Initial and Final Tests for

Experimental and Control Groups

	Mean Change	df	F ratio
Weight (lbs.)			
Experimental	1.21		
Control	- .55	28	3.21
Height (in.)			
Experimental	.10		
Control	.10	28	.00
Bust (in.)			
Experimental	.44		
Control	.24	28	.37
Waist (in.)			
Experimental	.40		
Control	.24	28	.66
Hips (in.)			
Experimental	.20		
Control	- .12	28	4.18
Upper Arm (in.)			
Experimental (right)	.14		
Control (right)	.08	28	.40
Experimental (left)	.25		
Control (left)	.05	28	2.99

Table IV

Summary of F Test for Mean Change

Between Initial and Final Tests for

Experimental and Control Groups

	Mean Change	df	F ratio
Thigh			
Experimental (right)	.48		
Control (right)	.64	28	.28
Experimental (left)	.51		
Control (left)	.55	28	.02
Calf			
Experimental (right)	- .15		
Control (right)	- .11	28	.26
Experimental (left)	- .13		
Control (left)	- .06	28	.80
Ankle			
Experimental (right)	- .02		
Control (right)	.00	28	.32
Experimental (left)	- .03		
Control (left)	- .03	28	.00

The experimental group showed a mean gain in hip size of .20 inch. The control group showed an average loss in hip size of .12 inch. This difference was not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On the upper arm the experimental group showed a mean gain of .14 inch on the right arm and .25 inch on the left arm. The control group showed a mean gain of .08 inch on the right arm and .05 inch on the left arm. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On the thigh the experimental group showed a mean gain of .48 inch on the right thigh and .51 inch on the left thigh. The control group showed a mean gain of .64 inch on the right thigh and .55 inch on the left thigh. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On the calf the experimental group showed a mean loss of .15 inch on the right calf and .13 inch on the left calf. The control group showed a mean loss of .11 inch on the right calf and .06 inch on the left calf. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

On the ankle the experimental group showed a mean loss of .02 inch on the right ankle and .03 inch on the left ankle. The

control group showed an average loss of .00 inch on the right ankle and .03 inch on the left ankle. These differences were not statistically significant at the five percent level of significance. The null hypothesis was not rejected.

Summary of Findings

Between Experimental and Control Groups

The F test indicated a statistically significant difference at the five percent level of significance on right knee flexion and on the six adipose tissue measurements: cheek, chest, arm, back, hip, and abdomen. There was no statistically significant difference on right or left elbow flexion, right or left elbow extension, left knee flexion, and right or left knee extension.

The F test indicated that there was no statistically significant difference on resting heart rate or any of the selected body measurements.

Chapter V

Summary

Problem

The purpose of this study was to determine the relative effects of a progressive weight training program on the arm and leg strength, resting heart rate, body adipose tissue, and selected body measurements of college freshman women.

Data

The subjects were 30 college freshman women who were selected randomly from 122 volunteers. The subjects were divided into two groups equated by a cable-tension strength test that was designed by the writer. The control and experimental groups were designated by use of the track pillbox method.

The experimental group completed 24 training sessions in a seven week period. Six exercise stations on the Marcy Gymnasium were used in the training program: lateral pull, bench press, military press, leg machine, pulley machine, and sit-ups on an incline board. The initial weight for each subject for a given exercise was determined by the writer through trial and error. Each subject selected a resistance (weight) which she could lift four or five times in one set and continued to exercise with that particular weight until she

could perform ten repetitions in one set. At this point in the training program the weight was increased. The subjects progressively added weight during the training program.

Twenty-eight variables—8 strength measurements, 6 adipose tissue measurements, 13 body measurements, and resting heart rate—were tested at the beginning and at the end of the seven week training program.

The data collected and recorded were statistically treated to determine the relative effects of a progressive weight training program on the arm and leg strength, resting heart rate, body adipose tissue, and selected body measurements. The analysis of data for this investigation dealt statistically with the variance or change within individuals between the initial and final tests. The difference between the experimental and control groups from initial and final tests was tested for significance at the five percent level of application of the F test.

Findings

Between Experimental and Control Groups

In the elbow flexion strength test the mean change of the experimental group increased; the average change of the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the elbow extension strength test the mean change of the experimental group increased; the mean change of the control

group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the knee flexion strength test the mean change of the experimental group increased; the mean change of the control group also increased. The difference between the two groups was statistically significant at the five percent level of significance for the right leg, but the difference was not statistically significant at the five percent level of significance for the left leg.

In the knee extension strength test the mean change of the experimental group increased; the mean change of the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the resting heart rate test for 30 seconds, the mean change of the experimental group decreased; the mean change of the control group also decreased. The difference between the two groups was not statistically significant at the five percent level.

In the cheek adipose tissue measurement test the mean change of the experimental group decreased; the mean change of the control group increased. The difference between the two groups was statistically significant at the five percent level.

In the chest adipose tissue measurement test the mean change of the experimental group decreased; the mean change of the control group also decreased. The difference between the two groups was statistically significant at the five percent level.

In the arm adipose tissue measurement test the mean change of the experimental group decreased; the mean change of the control group increased. The difference between the two groups was statistically significant at the five percent level.

In the back adipose tissue measurement test the mean change of the experimental group decreased; the mean change in the control group increased. The difference between the two groups was statistically significant at the five percent level.

In the hip adipose tissue measurement test the mean change of the experimental group decreased; the mean change in the control group also decreased. The difference between the two groups was statistically significant at the five percent level.

In the abdomen adipose tissue measurement test the mean change of the experimental group decreased; the mean change in the control group increased. The difference between the two groups was statistically significant at the five percent level.

In the body weight test the mean change of the experimental group increased; the mean change in the control group decreased. The difference between the two groups was not statistically significant at the five percent level.

In the body height test the mean change of the experimental group increased; the mean change in the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the bust measurement test the mean change of the experimental group increased; the mean change in the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the waist measurement test the mean change in the experimental group increased; the mean change in the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the hip measurement test the mean change in the experimental group increased; the mean change in the control group decreased. The difference between the two groups was not statistically significant at the five percent level.

In the upper arm measurement test the mean change in the experimental group increased; the mean change in the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the thigh measurement test the mean change in the experimental group increased; the mean change in the control group also increased. The difference between the two groups was not statistically significant at the five percent level.

In the calf measurement test the mean change in the experimental group decreased; the mean change in the control group also decreased. The difference between the two groups was not statistically significant at the five percent level.

In the ankle measurement test the mean change in the experimental group decreased; the mean change in the control group also decreased. The difference between the two groups was not statistically significant at the five percent level.

Conclusions

The findings of this study appear to indicate the following conclusions:

1. Both groups increased in strength development; however, the exercises used in the weight training program employed in this study did not produce a significant increase of strength in right or left elbow flexion, right or left elbow extension, left knee flexion, and right or left knee extension of the experimental group over the control group.

2. The weight training program as employed in this study had no significant effect on resting heart rate.

3. There was a significant loss of adipose tissue on the cheek, chest, arm, back, hip, and abdomen of the experimental weight training group.

4. The weight training program as employed in this study had no significant effect on any of the selected body measurements.

Implications of the Study

It is the investigator's opinion that weight training should be included in the Physical Education curriculum as an activity for

high school and college women. In addition to the findings of this study an informal survey of the experimental group subjects indicated 100% approval of weight training as an activity for girls and women. The subjects indicated they "felt better", seemed stronger, and had better body tone. These favorable attitudes toward weight training indicated that strenuous exercise for women is no longer viewed as being taboo. The subjects participating in the program felt that their femininity was in no way violated.

Recommendations for Further Study

The following are the investigator's recommendations for possible future study in the area of progressive weight training programs for women:

1. That a similar study be undertaken involving a longer training period and increasing the work load per session of training.

2. That a similar study be completed utilizing a trend analysis throughout the study.

3. That in future studies of this nature a critical consideration be given to the choice of the proper control group.

4. That additional studies concerning the physiological aspects of strenuous exercise on women be completed.

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APPENDIXES

APPENDIX A

RAW DATA: TO EQUATE GROUPS (POUNDS PULLED)

Subject Number	Bench Press	Leg Machine		Total
		Right	Left	
1	37	94	97	228
2	35	100	90	225
3	103	200	200	503
4	64	164	150	378
5	87	133	110	330
6	87	100	87	274
7	43	115	87	245
8	48	108	93	249
9	50	133	105	288
10	52	85	83	220
11	25	105	87	217
12	30	63	63	156
13	60	125	150	335
14	92	140	135	367
15	77	202	125	404
				$\bar{x}$ = 294.60
16	37	85	97	220
17	115	130	115	360
18	59	98	70	227
19	58	170	142	370
20	88	140	120	348
21	79	125	113	317
22	55	103	93	251
23	24	80	73	177
24	60	103	110	273
25	65	160	185	410
26	62	89	77	228
27	60	130	127	317
28	120	204	177	501
29	50	95	88	233
30	20	94	83	197
				$\bar{x}$ = 295.26

APPENDIX B

FORM FOR RECORDING STRENGTH MEASUREMENTS

STRENGTH - 3 Trials

Elbow Flexion

(Right) 1. _____ Reading
2. _____ Reading
3. _____ Reading
_____ Best
_____ Tension pounds

(Left) 1. _____ Reading
2. _____ Reading
3. _____ Reading
_____ Best
_____ Tension pounds

Elbow Extension

(Right) 1. _____ Reading
2. _____ Reading
3. _____ Reading
_____ Best
_____ Tension pounds

(Left) 1. _____ Reading
2. _____ Reading
3. _____ Reading
_____ Best
_____ Tension pounds

APPENDIX B (CONTINUED)

FORM FOR RECORDING STRENGTH MEASUREMENTS

STRENGTH - 3 Trials

Knee Flexion

(Right)		(Left)	
1. _____	Reading	1. _____	Reading
2. _____	Reading	2. _____	Reading
3. _____	Reading	3. _____	Reading
_____	Best	_____	Best
_____	Tension pounds	_____	Tension pounds

Knee Extension

(Right)		(Left)	
1. _____	Reading	1. _____	Reading
2. _____	Reading	2. _____	Reading
3. _____	Reading	3. _____	Reading
_____	Best	_____	Best
_____	Tension pounds	_____	Tension pounds

APPENDIX B (CONTINUED)

FORM FOR RECORDING ADIPOSE TISSUE MEASUREMENTS AND RESTING HEART RATE

ADIPOSE TISSUE:

Cheek:	_____	Chest:	_____	Arm:	_____
	_____		_____		_____
	_____		_____		_____
	_____ Total		_____ Total		_____ Total
	_____ Mean		_____ Mean		_____ Mean
Back:	_____	Abdomen:	_____	Hip:	_____
	_____		_____		_____
	_____		_____		_____
	_____ Total		_____ Total		_____ Total
	_____ Mean		_____ Mean		_____ Mean

RESTING HEART RATE FOR 30 SECONDS _____

APPENDIX B (CONTINUED)

FORM FOR RECORDING BODY MEASUREMENTS

BODY MEASUREMENTS:

Height _____

Weight _____

Bust _____

Waist _____

Hips _____

Upper Arm (right) _____

Upper Arm (left) _____

Thigh (right) _____

Thigh (left) _____

Calf (right) _____

Calf (left) _____

Ankle (right) _____

Ankle (left) _____

APPENDIX C

DESCRIPTION OF WARM-UP EXERCISES

Jumping Jacks

The subject assumed a starting position by standing with feet together and arms at her sides. On count one the subject jumped and landed with feet apart, touching her hands above the head. On count two she returned to the starting position. Ten repetitions were made.

Running-in-place

The subject ran in place at a moderate pace for 30 seconds.

Leg Thrust

The subject began by crouching on the floor with her weight supported on the hands and toes, a position similar to that of a runner in a starting block. The left foot was bent and under the body, with the right foot extended to the rear. At the count of one the subject jumped slightly, shifting the feet so that the right foot was bent and under the body and the left foot extended to the rear. At the count of two the subject shifted again and returned to the original position. Ten repetitions were executed.

APPENDIX D

DESCRIPTION OF WEIGHT TRAINING EXERCISES USING THE MARCY GYMNASIUM

Lateral Pull (Figure 4, Station 1)

Each subject assumed a kneeling position with arms extended above the head and both hands clasping an exercise bar; the hands were in prone position. The execution of the exercise was accomplished by pulling the bar down to and behind the neck, and then returning to the starting position. The exercise was repeated.

Bench Press (Figure 4, Station 2)

Each subject assumed a supine position on a bench. Directly above and parallel with the subject's shoulders was an exercise bar. The execution of the exercise was accomplished by clasping the bar with both hands and pushing upward until the arms were completely extended. Then the bar was lowered to the starting position. The exercise was repeated.

Military Press (Figure 4, Station 3)

Each subject assumed a sitting position on a stool under an exercise bar. The bar was parallel with the shoulders. The execution of the exercise was accomplished by clasping the bar with both hands and pushing upward on the bar until the arms were completely extended. Then the bar was again lowered to the starting position. The exercise was repeated.

APPENDIX D (CONTINUED)

Leg Machine (Figure 4, Station 4)

For the quadriceps exercise the subject assumed the correct position by resting her shoulders on the shoulder pads provided on the Marcy Gymnasium and clasping the framework of the machine. Each foot was placed on the correct foot pedal. The execution of the exercise was accomplished when the subject alternately pushed backward, extending each leg completely. (One leg would move backward to full extension while the opposite leg would move forward and assume a flexed position.) The exercise was repeated.

For the hamstring exercise the subject assumed the correct position by standing at arm's length from the Marcy Gymnasium with her hands resting on the machine. The subject stood on a supporting leg, with the other leg placed on a foot pedal. The execution of the exercise was accomplished by a backward pulling action of the leg on the foot pedal. The leg was extended and again returned to a flexed starting position. The exercise was repeated.

Sit-ups (Figure 4, Station 5)

The subject assumed a sitting position with knees flexed and feet under a strap which was located on the incline sit-up board. Hands were clasped and placed behind the subject's head. The execution of the exercise was accomplished by lowering the subject's back to the board and again assuming the starting position.

When the subject could perform 10 sit-ups on the board at an incline of 10, she again returned to an incline of 1, doing sit-ups with a weight placed behind her head.

Pulley-Machine (Figure 4, Station 6)

For the bicep curls the subject assumed a starting position by standing and facing the machine. The arms were extended at the subject's sides, and a pulley was in each hand; the hands were in a supine position. The execution of the exercise was accomplished by pulling upward with the pulleys until the arms were completely flexed. The exercise was repeated.

For the tricep extensions the subject assumed a starting position by standing and facing the machine. The arms were extended at each subject's sides, and a pulley was in each hand; the hands were in a supine position. The execution of the exercise was accomplished by extending the arms as far backward as possible. The exercise was repeated.

APPENDIX B

RAW DATA: PROGRAM--INITIAL AND FINAL WEIGHTS

Subject Number	Lateral Pull				Bench Press			
	Initial		Final		Initial		Final	
	Wt.	Reps.	Wt.	Reps.	Wt.	Reps.	Wt.	Reps.
1	40	5	80	9	20	5	50	10
2	70	5	100	4	40	4	55	6
3	60	5	90	7	30	5	60	5
4	50	5	90	10	40	5	60	8
5	40	5	90	7	30	5	70	7
6	60	5	90	10	40	5	50	10
7	40	5	70	8	30	5	50	7
8	40	5	80	6	20	5	50	6
9	50	5	100	5	30	5	60	8
10	50	5	90	5	35	5	65	10
11	30	5	70	10	20	5	50	8
12	50	5	90	8	30	5	55	10
13	50	5	100	10	40	5	70	8
14	50	5	90	8	30	5	60	7
15	40	5	70	8	20	5	45	10

Subject Number	Military Press			
	Initial		Final	
	Wt.	Reps.	Wt.	Reps.
1	30	5	50	7
2	40	5	50	10
3	40	5	60	3
4	40	5	50	10
5	30	5	60	10
6	40	5	50	5
7	30	5	50	5
8	30	5	50	8
9	30	5	60	5
10	40	5	60	7
11	30	5	50	8
12	40	5	50	10
13	40	5	60	7
14	40	5	50	9
15	30	5	40	10

APPENDIX E (CONTINUED

Leg Machine
(Quadriceps Exercise)

Subject Number	Initial Right Wt.	Initial Right Reps.	Initial Left Wt.	Initial Left Reps.	Final Right Wt.	Final Right Reps.	Final Left Wt.	Final Left Reps.
1	20	5	30	5	60	8	60	8
2	40	5	40	5	80	10	80	10
3	40	5	40	5	80	5	80	5
4	40	5	40	5	70	5	70	5
5	30	5	30	5	80	10	80	10
6	50	5	40	5	80	7	80	7
7	30	5	30	5	70	7	70	7
8	30	5	30	5	70	3	70	3
9	40	5	40	5	100	8	100	8
10	50	5	50	5	80	6	80	6
11	30	5	30	5	60	10	60	10
12	40	5	40	5	70	10	70	10
13	40	5	40	5	90	10	90	10
14	30	5	30	5	80	10	80	10
15	30	5	40	5	60	10	60	10

Leg Machine
(Hamstring Exercise)

1	20	5	20	5	50	6	50	6
2	40	5	40	5	60	5	60	5
3	30	5	30	5	50	8	50	8
4	30	5	30	5	50	9	50	6
5	20	5	30	5	60	5	60	5
6	40	5	40	5	60	5	60	5
7	30	5	30	5	50	10	50	10
8	30	5	30	5	50	8	50	8
9	30	5	30	5	60	5	60	5
10	40	5	40	5	50	10	50	10
11	20	5	30	5	50	7	40	10
12	30	5	30	5	50	10	50	5
13	40	5	40	5	60	10	60	8
14	30	5	30	5	50	8	50	6
15	30	5	30	5	40	10	40	10

APPENDIX B (CONTINUED)

Sit-ups

Subject Number	Initial Incline	Initial Reps.	Initial Wt.	Final Incline	Final Reps.	Final Wt.
1	1	5	0	6	7	0
2	5	5	0	9	4	0
3	5	5	0	9	6	0
4	2	5	0	2	10	0
5	6	5	0	9	6	0
6	3	5	0	7	5	0
7	6	5	0	3	9	10
8	5	5	0	7	7	0
9	2	5	0	7	5	0
10	6	5	0	6	5	10
11	6	5	0	6	10	0
12	8	5	0	6	6½	10
13	9	5	0	6	10	10
14	6	5	0	10	8	0
15	4	5	0	10	6	0

APPENDIX B (CONTINUED)

Pulley Machine
(Bicep Curls)

	Initial				Final			
	Right		Left		Right		Left	
Subject Number	Wt.	Reps.	Wt.	Reps.	Wt.	Reps.	Wt.	Reps.
1	20	5	20	5	40	7	40	7
2	30	5	20	5	40	4	40	4
3	30	5	20	5	40	5	40	5
4	20	5	20	5	40	7	40	7
5	20	5	20	5	40	8	40	8
6	30	5	30	5	40	5	40	5
7	20	5	20	5	30	8	30	8
8	20	5	20	5	40	5	40	5
9	20	5	20	5	40	6	40	6
10	30	5	30	5	40	6	40	6
11	20	5	20	5	40	5	40	5
12	20	5	20	5	40	6	40	6
13	20	5	20	5	50	10	50	10
14	30	5	30	5	50	5	50	5
15	30	5	20	5	40	6	40	6

Pulley Machine
(Tricep Extensions)

1	10	5	10	5	20	10	20	10
2	20	5	20	5	20	10	20	10
3	10	5	10	5	20	10	20	10
4	10	5	10	5	30	10	30	10
5	10	5	10	5	30	10	30	10
6	10	5	10	5	30	10	30	10
7	10	5	10	5	30	5	30	5
8	10	5	10	5	20	10	20	10
9	10	5	10	5	30	10	30	10
10	10	5	10	5	30	10	30	10
11	10	5	10	5	30	10	30	10
12	10	5	10	5	30	10	30	10
13	10	5	10	5	30	10	30	10
14	10	5	10	5	30	10	30	10
15	10	5	10	5	30	10	30	10

APPENDIX F

RAW DATA: ELBOW FLEXION (POUNDS PULLED)

Experimental Group

Subject Number	Initial Test		Final Test	
	Right	Left	Right	Left
1	59	53	65	67
2	75	77	97	95
3	60	61	97	97
4	67	61	89	67
5	75	74	89	67
6	75	75	89	97
7	59	63	56	61
8	50	75	64	55
9	73	64	89	70
10	60	67	89	77
11	68	64	73	73
12	75	60	75	90
13	92	92	117	89
14	89	77	117	120
15	77	60	85	80
	$\bar{x}$ = 70.26	$\bar{x}$ = 68.20	$\bar{x}$ = 86.06	$\bar{x}$ = 80.33

Control Group

1	80	87	90	95
2	61	70	80	77
3	85	85	120	95
4	77	75	135	100
5	80	73	95	93
6	77	70	97	77
7	37	38	60	56
8	67	83	100	105
9	80	77	96	67
10	60	67	94	77
11	73	76	64	67
12	56	61	70	70
13	63	65	115	118
14	95	87	103	103
15	90	77	77	83
	$\bar{x}$ = 72.06	$\bar{x}$ = 72.40	$\bar{x}$ = 93.00	$\bar{x}$ = 85.53

APPENDIX F (CONTINUED)

RAW DATA: ELBOW EXTENSION
(POUNDS PULLED)

Experimental Group

Subject Number	Initial Test		Final Test	
	Right	Left	Right	Left
1	33	30	35	33
2	45	53	53	59
3	55	37	53	38
4	48	40	53	53
5	37	35	53	35
6	63	45	59	56
7	37	40	56	38
8	31	23	37	35
9	37	47	59	53
10	30	45	50	45
11	42	38	53	60
12	59	53	43	50
13	50	57	67	65
14	45	43	75	77
15	38	33	37	43
	$\bar{x}$ = 43.33	$\bar{x}$ = 41.26	$\bar{x}$ = 52.20	$\bar{x}$ = 49.33

Control Group

1	43	50	53	63
2	50	50	40	48
3	43	60	60	56
4	33	38	45	65
5	53	50	59	40
6	55	48	61	53
7	31	30	43	37
8	43	40	45	53
9	50	43	61	60
10	45	38	45	50
11	31	33	33	34
12	25	31	34	35
13	40	35	55	50
14	50	50	63	65
15	60	61	38	40
	$\bar{x}$ = 43.46	$\bar{x}$ = 43.80	$\bar{x}$ = 49.00	$\bar{x}$ = 49.93

APPENDIX F (CONTINUED)

RAW DATA: KNEE FLEXION (POUNDS PULLED)

Experimental Group

Subject Number	Initial Test		Final Test	
	Right	Left	Right	Left
1	65	65	74	85
2	120	125	135	160
3	85	77	105	110
4	73	73	93	100
5	82	88	88	88
6	90	89	140	167
7	95	102	98	105
8	67	64	73	77
9	128	105	145	130
10	85	82	93	88
11	98	130	123	145
12	59	59	105	110
13	100	93	163	153
14	125	94	132	132
15	92	89	85	80
	$\bar{x}$ = 90.93	$\bar{x}$ = 89.00	$\bar{x}$ = 110.13	$\bar{x}$ = 115.33

Control Group

1	77	65	82	90
2	90	89	100	90
3	105	88	120	138
4	135	145	135	150
5	138	108	145	163
6	100	130	105	124
7	60	65	66	68
8	89	94	105	127
9	89	89	100	132
10	89	75	82	92
11	61	53	85	90
12	60	50	73	45
13	110	77	105	120
14	103	108	113	120
15	89	83	95	100
	$\bar{x}$ = 93.00	$\bar{x}$ = 87.93	$\bar{x}$ =100.73	$\bar{x}$ = 109.93

APPENDIX F (CONTINUED)

RAW DATA: KNEE EXTENSION
(POUNDS PULLED)

Experimental Group

Subject Number	Initial Test		Final Test	
	Right	Left	Right	Left
1	160	130	190	160
2	200	200	235	270
3	117	113	183	160
4	145	160	187	204
5	235	220	255	216
6	190	170	195	208
7	218	173	220	200
8	102	73	135	145
9	210	185	216	170
10	220	187	245	212
11	157	167	216	216
12	173	200	167	204
13	204	185	270	255
14	180	167	255	216
15	140	110	190	183
	$\bar{x}$ = 176.73	$\bar{x}$ = 162.66	$\bar{x}$ = 210.60	$\bar{x}$ = 201.26

Control Group

1	163	157	175	150
2	160	142	187	170
3	204	240	220	260
4	260	255	285	280
5	218	220	235	255
6	189	163	212	200
7	107	108	137	132
8	220	190	290	253
9	173	143	200	208
10	177	163	187	150
11	100	89	120	117
12	100	95	123	130
13	207	173	245	216
14	160	157	204	200
15	215	217	216	220
	$\bar{x}$ = 176.86	$\bar{x}$ = 167.46	$\bar{x}$ = 202.40	$\bar{x}$ = 196.06

APPENDIX G

RAW DATA: RESTING HEART RATE (30 sec.)

Experimental Group

Subject Number	Initial Test	Final Test
1	32	34
2	34	33
3	48	45
4	36	46
5	47	43
6	44	46
7	50	44
8	48	44
9	42	37
10	43	41
11	48	50
12	42	47
13	32	30
14	32	31
15	45	45
	$\bar{x} = 41.53$	$\bar{x} = 41.06$

Control Group

1	44	42
2	38	31
3	39	32
4	42	42
5	33	37
6	38	38
7	42	40
8	36	34
9	49	39
10	41	39
11	53	37
12	36	32
13	36	39
14	34	32
15	44	43
	$\bar{x} = 40.33$	$\bar{x} = 37.13$

APPENDIX H

RAW DATA: ADIPOSE TISSUE (centimeters)

Experimental Group

Subject Number	Cheek		Chest		Arm	
	Initial	Final	Initial	Final	Initial	Final
1	.39	.39	.19	.14	.33	.32
2	.41	.40	.21	.20	.27	.26
3	.62	.39	.20	.15	.31	.24
4	.53	.34	.17	.17	.20	.21
5	.53	.40	.22	.16	.17	.20
6	.44	.32	.16	.14	.20	.18
7	.46	.27	.15	.12	.23	.19
8	.13	.12	.14	.11	.19	.16
9	.31	.27	.21	.14	.26	.15
10	.39	.31	.19	.13	.15	.19
11	.35	.26	.21	.16	.21	.21
12	.10	.10	.23	.17	.20	.16
13	.53	.48	.20	.15	.16	.17
14	.70	.35	.21	.19	.48	.21
15	.62	.33	.21	.15	.39	.16
	$\bar{x}$ = .43	$\bar{x}$ = .32	$\bar{x}$ = .19	$\bar{x}$ = .15	$\bar{x}$ = .25	$\bar{x}$ = .20

Control Group

1	.35	.36	.16	.12	.19	.19
2	.40	.49	.20	.18	.21	.24
3	.35	.34	.16	.15	.20	.21
4	.39	.43	.20	.17	.20	.16
5	.14	.13	.19	.20	.25	.24
6	.30	.35	.18	.17	.20	.17
7	.43	.52	.17	.15	.17	.17
8	.29	.31	.14	.15	.12	.14
9	.50	.36	.20	.18	.21	.23
10	.33	.33	.25	.16	.15	.22
11	.40	.39	.20	.18	.17	.20
12	.31	.32	.16	.16	.19	.20
13	.53	.46	.20	.16	.19	.21
14	.43	.52	.17	.21	.20	.24
15	.52	.50	.21	.18	.18	.24
	$\bar{x}$ = .38	$\bar{x}$ = .39	$\bar{x}$ = .19	$\bar{x}$ = .17	$\bar{x}$ = .19	$\bar{x}$ = .20

APPENDIX H (CONTINUED)

Experimental Group

Subject Number	Back		Hip		Abdomen	
	Initial	Final	Initial	Final	Initial	Final
1	.36	.31	.23	.26	.26	.22
2	.30	.32	.29	.27	.31	.29
3	.34	.21	.41	.29	.63	.38
4	.27	.29	.28	.22	.25	.22
5	.50	.31	.26	.22	.37	.31
6	.29	.29	.22	.18	.40	.29
7	.23	.19	.23	.21	.29	.24
8	.29	.13	.32	.20	.44	.29
9	.28	.11	.35	.22	.41	.23
10	.22	.18	.24	.20	.41	.21
11	.10	.08	.25	.24	.54	.28
12	.23	.22	.34	.23	.40	.29
13	.17	.17	.21	.17	.38	.28
14	.61	.40	.41	.22	.55	.33
15	.21	.18	.32	.23	.37	.29
	$\bar{x}$ = .29	$\bar{x}$ = .23	$\bar{x}$ = .29	$\bar{x}$ = .22	$\bar{x}$ = .40	$\bar{x}$ = .28

Control Group

1	.31	.35	.24	.25	.29	.25
2	.18	.38	.22	.23	.35	.35
3	.11	.39	.25	.23	.42	.39
4	.10	.10	.33	.25	.45	.40
5	.43	.50	.28	.31	.40	.50
6	.13	.31	.31	.31	.41	.48
7	.29	.32	.25	.23	.39	.40
8	.23	.34	.15	.24	.31	.35
9	.32	.26	.28	.31	.30	.37
10	.25	.34	.29	.29	.47	.45
11	.28	.38	.23	.23	.31	.33
12	.19	.20	.28	.23	.38	.42
13	.47	.50	.27	.23	.34	.32
14	.36	.52	.27	.23	.33	.42
15	.36	.46	.23	.30	.36	.47
	$\bar{x}$ = .27	$\bar{x}$ = .36	$\bar{x}$ = .26	$\bar{x}$ = .26	$\bar{x}$ = .37	$\bar{x}$ = .40

APPENDIX I

RAW DATA: BODY WEIGHT AND HEIGHT
(lbs.) (in.)

Experimental Group

Subject Number	Weight		Height	
	Initial	Final	Initial	Final
1	113.50	117.12	64.00	64.00
2	189.25	184.75	69.25	69.25
3	127.25	131.75	63.00	63.00
4	143.75	144.75	67.50	67.75
5	120.25	119.75	63.25	63.50
6	156.75	158.25	69.25	69.25
7	126.00	127.25	63.50	63.75
8	105.50	106.25	64.00	64.25
9	155.50	157.75	65.25	65.25
10	146.00	148.25	67.50	67.50
11	122.75	121.50	63.50	63.75
12	146.75	147.50	64.75	65.00
13	141.25	142.12	67.25	67.25
14	137.75	139.75	65.50	65.50
15	112.50	116.50	66.25	66.25
	$\bar{x}$ = 136.32	$\bar{x}$ = 137.53	$\bar{x}$ = 65.58	$\bar{x}$ = 65.68

Control Group

1	106.00	105.25	64.00	64.00
2	130.25	132.12	66.00	66.00
3	135.00	135.12	65.00	65.00
4	137.50	137.12	66.00	66.25
5	157.50	153.87	66.50	66.75
6	161.75	162.25	65.25	65.50
7	129.50	125.00	65.25	65.25
8	144.75	152.75	65.50	65.50
9	139.75	139.00	64.25	64.25
10	124.00	124.00	62.00	62.25
11	155.75	152.50	67.00	67.12
12	100.50	100.25	62.50	62.50
13	124.00	125.50	64.25	64.50
14	175.50	172.50	68.25	68.50
15	140.75	137.00	66.25	66.12
	$\bar{x}$ = 137.50	$\bar{x}$ = 136.95	$\bar{x}$ = 65.20	$\bar{x}$ = 65.30

APPENDIX J

RAW DATA: BODY GIRTH (inches)

Experimental Group

Subject Number	Bust		Waist		Hips	
	Initial	Final	Initial	Final	Initial	Final
1	32.37	34.25	26.00	27.12	36.37	36.50
2	40.75	39.87	34.63	33.87	44.00	43.75
3	35.50	37.37	29.00	29.50	37.00	37.75
4	37.12	37.50	30.75	31.37	39.25	39.25
5	35.00	35.25	26.50	26.12	37.00	36.25
6	37.75	39.50	28.63	29.00	42.12	43.00
7	33.75	33.37	27.50	28.12	38.75	39.25
8	33.25	33.00	23.87	23.63	35.75	35.63
9	39.50	39.25	29.63	31.00	40.25	40.50
10	36.00	36.75	27.75	28.63	40.63	40.50
11	35.00	35.12	26.00	26.37	38.00	38.18
12	39.00	38.75	30.25	30.75	40.50	40.50
13	36.00	35.87	29.00	29.25	38.75	38.87
14	34.75	35.63	28.00	28.50	39.25	40.00
15	31.00	31.87	24.50	24.87	36.00	36.75
	$\bar{x}$ = 35.78	$\bar{x}$ = 36.22	$\bar{x}$ = 28.13	$\bar{x}$ = 28.53	$\bar{x}$ = 38.91	$\bar{x}$ = 39.11

Control Group

1	31.75	32.00	24.25	24.75	34.00	34.00
2	33.75	34.12	25.25	26.12	37.50	38.00
3	35.50	36.12	26.50	27.12	39.50	39.00
4	36.50	36.25	28.25	28.63	38.75	38.37
5	36.50	36.63	29.75	30.12	40.87	40.25
6	37.50	37.12	27.75	27.50	44.00	44.12
7	35.00	34.63	26.25	26.00	37.75	37.50
8	35.00	38.37	27.37	29.00	40.25	40.37
9	36.00	36.12	29.00	28.50	39.00	39.00
10	36.87	36.12	25.87	26.50	37.12	37.12
11	35.75	35.63	29.00	28.75	41.75	41.00
12	31.75	32.00	23.25	23.37	35.50	35.25
13	34.75	35.00	28.00	28.00	38.00	38.00
14	39.50	39.75	34.00	33.75	41.50	42.25
15	36.37	36.25	27.87	27.87	39.50	38.87
	$\bar{x}$ = 35.50	$\bar{x}$ = 35.74	$\bar{x}$ = 28.16	$\bar{x}$ = 28.40	$\bar{x}$ = 39.00	$\bar{x}$ = 38.88

APPENDIX J (CONTINUED)

Experimental Group

Subject Number	Upper Arm Initial Right	Initial Left	Final Right	Final Left
1	9.87	10.00	10.00	10.12
2	13.25	13.00	12.87	12.75
3	11.00	10.87	11.63	11.50
4	10.50	10.25	10.63	10.37
5	10.25	10.00	10.75	10.63
6	11.50	11.25	12.00	11.75
7	11.50	11.50	11.37	11.75
8	9.12	8.87	9.00	8.87
9	12.50	12.12	12.50	12.37
10	11.00	11.00	10.75	11.00
11	10.25	9.87	10.37	10.25
12	11.50	11.75	11.50	11.63
13	10.50	10.12	10.87	10.75
14	10.00	9.75	10.12	10.12
15	9.12	8.75	9.63	9.12
	$\bar{x}$ = 10.79	$\bar{x}$ = 10.61	$\bar{x}$ = 10.93	$\bar{x}$ = 10.86

Control Group

1	9.63	10.50	9.50	9.63
2	10.00	9.75	10.12	9.87
3	11.50	11.50	11.63	11.87
4	10.25	10.12	10.25	10.25
5	11.50	11.37	11.12	11.25
6	12.12	12.25	12.12	12.25
7	10.63	10.63	10.37	10.37
8	11.25	11.12	11.37	11.63
9	11.25	11.12	11.37	11.25
10	10.37	10.50	10.75	10.63
11	11.75	11.50	12.12	11.75
12	9.25	9.63	9.37	9.37
13	10.00	10.00	10.37	10.75
14	12.50	13.00	12.75	12.87
15	10.75	10.75	10.75	10.75
	$\bar{x}$ = 10.85	$\bar{x}$ = 10.92	$\bar{x}$ = 10.93	$\bar{x}$ = 10.97

APPENDIX J (CONTINUED)

Experimental Group

Thigh

Subject Number	Initial		Final	
	Right	Left	Right	Left
1	20.87	20.50	21.25	21.25
2	37.37	27.12	27.25	27.00
3	20.87	20.50	22.37	21.87
4	22.75	22.63	23.12	23.25
5	20.25	20.12	21.50	21.12
6	24.63	24.50	24.87	25.00
7	23.25	22.63	23.00	22.63
8	19.25	19.00	19.63	19.37
9	24.12	24.00	25.25	24.50
10	23.87	23.25	21.75	22.00
11	22.25	21.75	22.12	21.50
12	24.75	24.50	24.50	24.50
13	23.00	23.00	23.63	23.50
14	20.50	19.75	22.87	22.25
15	19.00	19.25	20.75	21.25
	$\bar{x}$ = 21.78	$\bar{x}$ = 22.17	$\bar{x}$ = 22.26	$\bar{x}$ = 22.68

Control Group

1	19.25	19.63	20.12	20.12
2	23.00	22.63	24.00	23.37
3	22.25	22.00	23.37	23.50
4	22.75	22.63	22.63	22.63
5	25.63	26.00	25.87	26.00
6	26.50	26.00	27.12	26.75
7	22.25	22.12	21.75	21.50
8	23.25	23.37	25.37	25.00
9	23.25	23.00	23.25	23.12
10	21.37	21.12	22.00	21.25
11	24.87	25.00	25.25	25.12
12	19.50	19.25	20.25	20.12
13	20.25	20.25	22.00	22.00
14	24.50	25.00	24.87	25.25
15	22.87	22.50	23.37	23.12
	$\bar{x}$ = 22.77	$\bar{x}$ = 22.70	$\bar{x}$ = 23.41	$\bar{x}$ = 23.25

APPENDIX J (CONTINUED)

Experimental Group

Subject Number	Calf			
	Initial		Final	
	Right	Left	Right	Left
1	12.50	12.12	12.50	12.12
2	15.75	15.63	15.87	15.63
3	13.75	13.25	13.63	13.25
4	13.25	13.50	13.25	13.37
5	13.50	13.63	13.37	13.75
6	14.37	14.63	14.25	14.50
7	13.75	13.50	13.37	12.87
8	12.12	11.87	12.00	11.87
9	15.50	15.25	15.00	14.50
10	14.12	14.12	13.87	13.87
11	12.12	12.37	12.37	12.25
12	14.50	14.50	14.25	14.25
13	14.00	13.75	13.63	13.63
14	14.50	14.50	14.37	14.63
15	13.50	12.87	13.63	13.00
	$\bar{x}$ = 13.82	$\bar{x}$ = 13.70	$\bar{x}$ = 13.67	$\bar{x}$ = 13.57

Control Group

1	12.87	12.87	12.63	12.63
2	13.75	13.50	13.75	13.75
3	13.25	13.50	13.25	13.63
4	13.25	13.87	13.25	13.63
5	14.75	14.63	14.37	14.25
6	16.25	16.12	16.00	16.00
7	13.87	13.63	13.63	13.63
8	15.25	15.00	15.50	15.37
9	15.00	14.75	14.75	14.50
10	13.63	13.50	13.63	13.50
11	14.63	14.63	14.25	14.50
12	12.50	12.25	12.37	12.25
13	13.50	13.63	13.63	13.50
14	15.25	15.50	15.00	15.50
15	13.75	13.63	13.75	13.50
	$\bar{x}$ = 14.10	$\bar{x}$ = 14.07	$\bar{x}$ = 13.99	$\bar{x}$ = 14.01

APPENDIX J (CONTINUED)

Experimental Group

Subject Number	Ankle			
	Initial		Final	
	Right	Left	Right	Left
1	7.63	7.75	7.75	7.75
2	9.12	9.25	9.12	9.12
3	8.00	8.00	8.00	8.00
4	8.63	8.75	8.63	8.75
5	8.37	8.37	8.37	8.37
6	9.00	9.12	9.00	9.12
7	8.12	7.87	8.00	7.75
8	7.75	7.63	7.63	7.50
9	9.50	9.50	9.50	9.50
10	9.00	9.00	9.00	9.00
11	8.25	8.12	8.12	8.00
12	8.50	8.50	8.50	8.50
13	8.25	8.25	8.12	8.12
14	9.12	9.25	9.12	9.25
15	8.25	8.12	8.25	8.25
	$\bar{x}$ = 8.50	$\bar{x}$ = 8.50	$\bar{x}$ = 8.48	$\bar{x}$ = 8.47

Control Group

1	7.87	8.00	8.00	8.00
2	8.50	8.37	8.50	8.25
3	8.37	8.50	8.50	8.50
4	8.63	8.87	8.63	8.75
5	8.50	8.75	8.50	8.63
6	9.75	9.63	9.50	9.37
7	8.12	8.12	8.12	8.12
8	9.50	9.50	9.63	9.63
9	9.37	9.37	9.37	9.37
10	8.00	7.87	8.00	7.87
11	9.12	9.12	9.12	9.12
12	7.37	7.37	7.25	7.37
13	8.25	8.25	8.12	8.25
14	9.00	9.00	9.00	9.00
15	8.50	8.37	8.50	8.37
	$\bar{x}$ = 8.59	$\bar{x}$ = 8.61	$\bar{x}$ = 8.59	$\bar{x}$ = 8.58